



Computational Modeling of Space Physiology

Beth E. Lewandowski and DeVon W. Griffin, NASA Glenn Research Center, Cleveland, OH 44135



NASA Digital Astronaut Project Team: K Gilkey, NASA GRC; J DeWitt, Wyle Science, Technology and Engineering Group; J Myers, NASA GRC; E Nelson, NASA GRC; J Pennline, NASA GRC; W Thompson, NASA GRC; C Gallo, NASA GRC; D Munster, NASA GRC; O Gad, NASA GRC; K Jagodnik, Baylor College of Medicine; B Humphreys, ZIN Technologies Inc; C Werner, ZIN Technologies Inc; A Godfrey, ZIN Technologies Inc

BACKGROUND

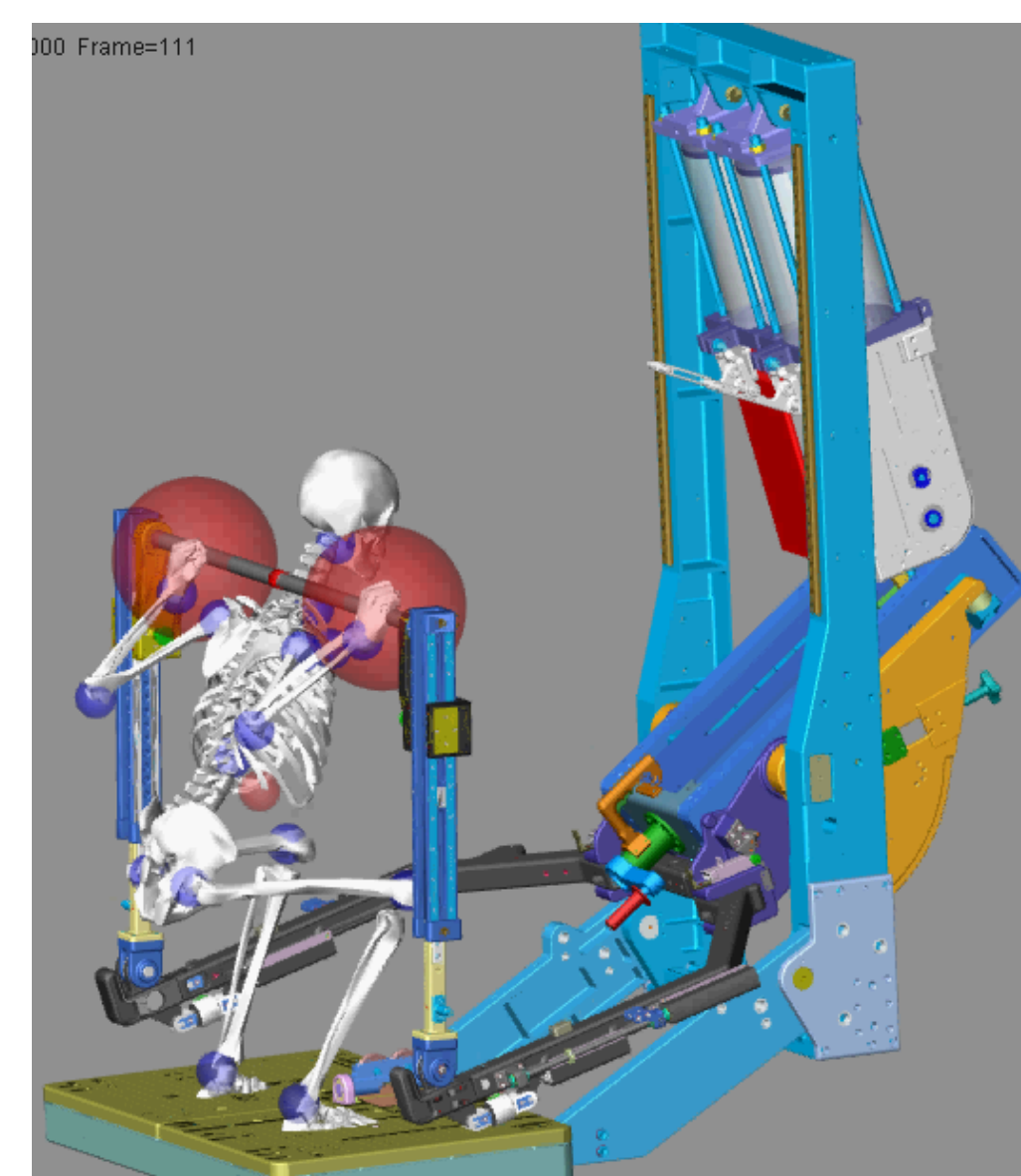
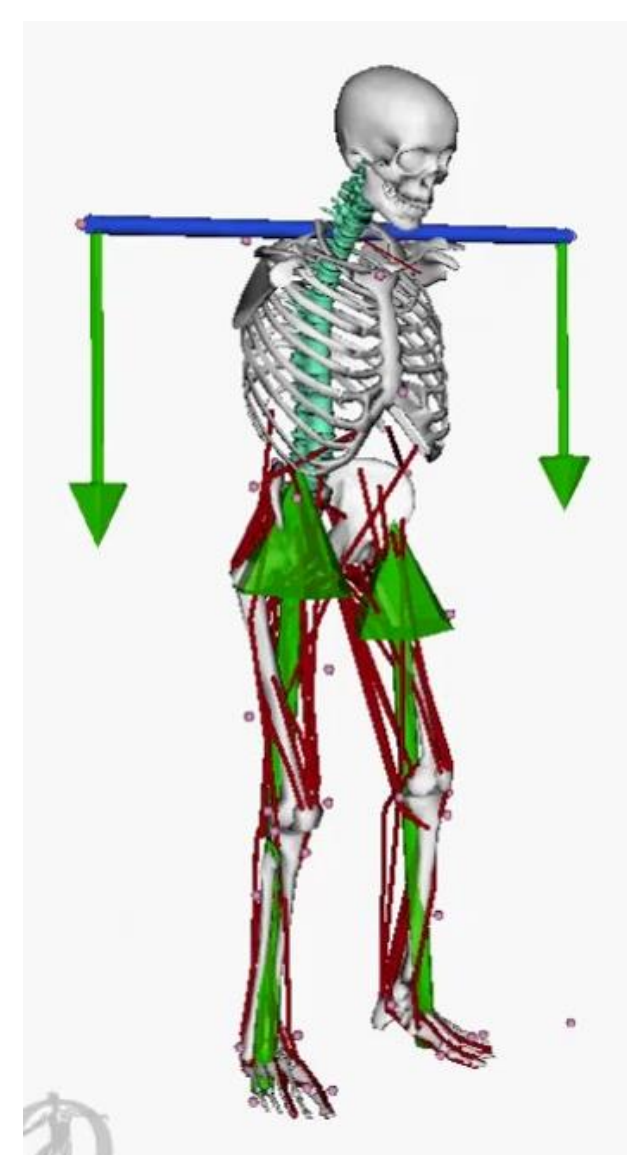
The NASA Digital Astronaut Project (DAP) develops and implements well-vetted computational models to predict and assess spaceflight health and performance risks and enhance countermeasure development

DAP performs computational modeling in the following areas:

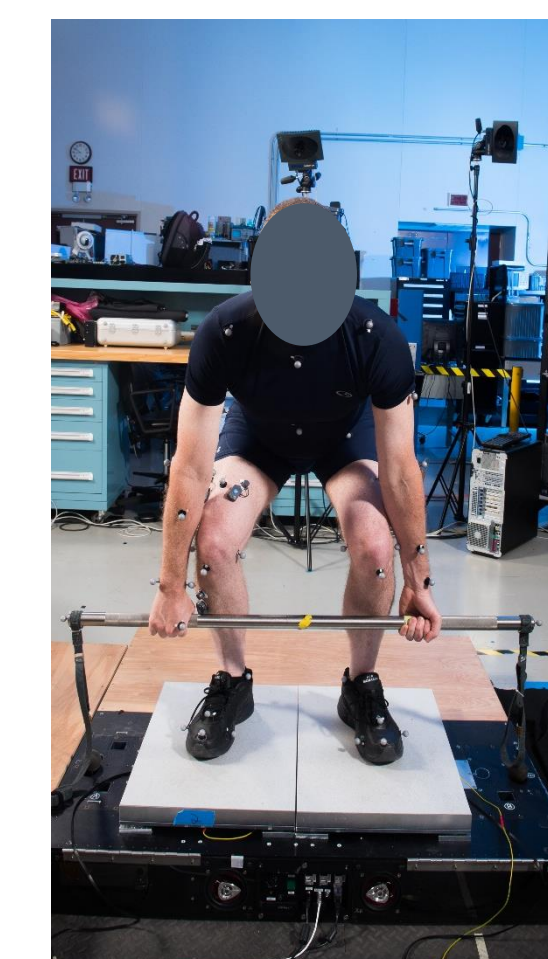
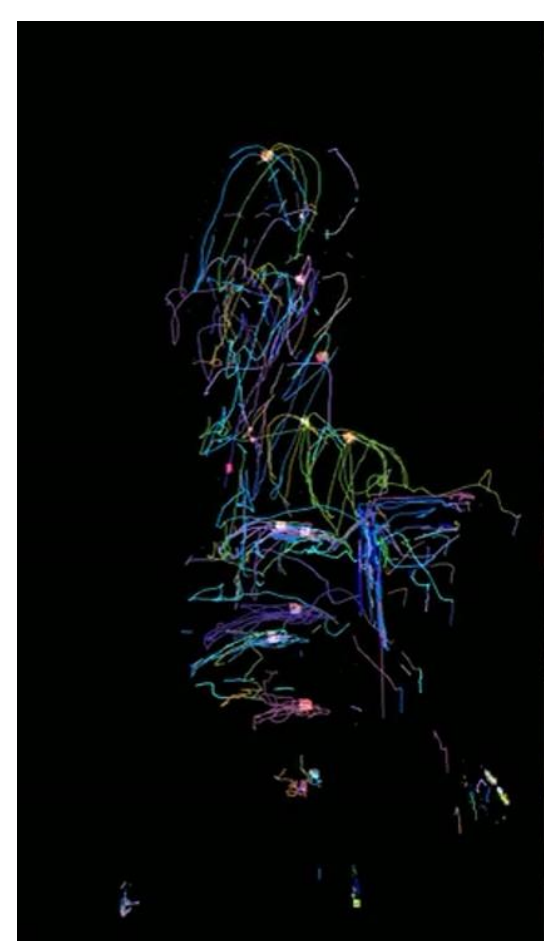
- Biomechanical modeling of spaceflight exercise devices
- Changes in bone mineral density and bone fracture probability
- Muscle atrophy and changes in muscle performance
- A lumped-parameter model of the cardiovascular system
- Ocular modeling of the visual impairment and intracranial pressure syndrome

BIOMECHANICAL MODELS

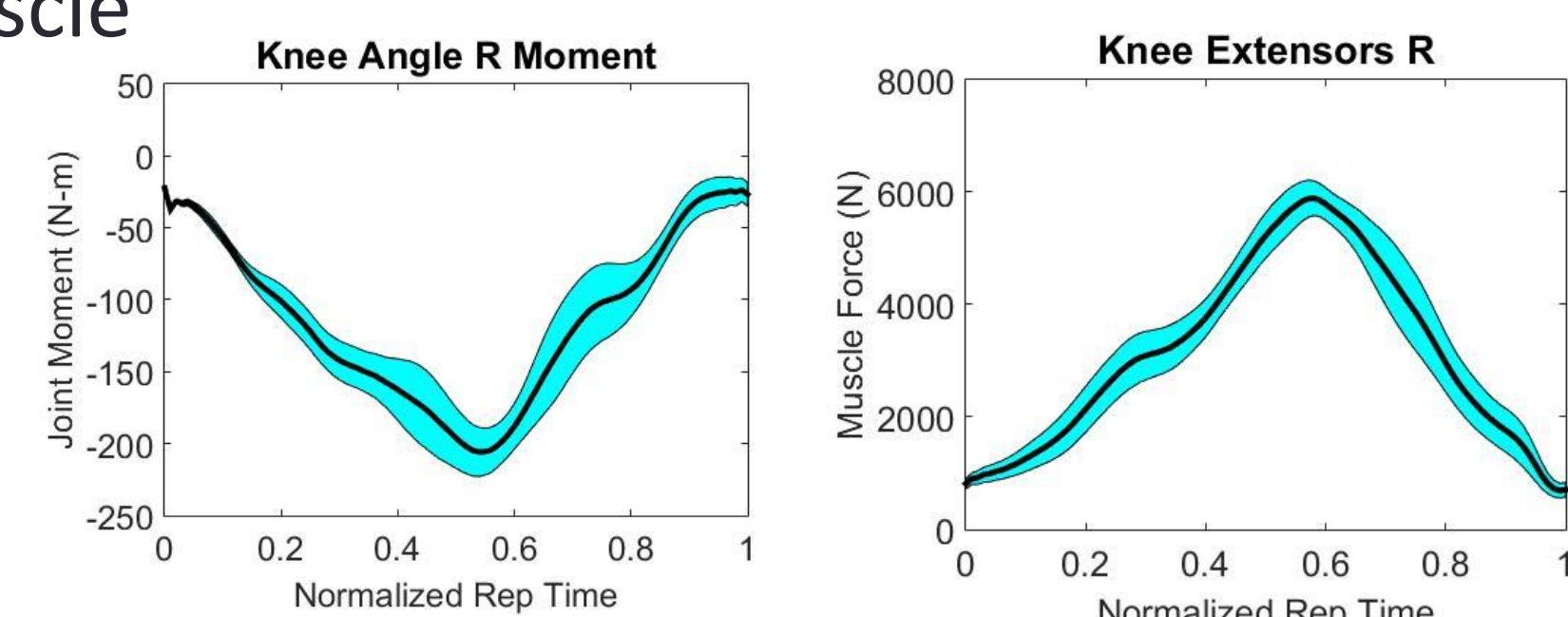
Biomechanical modeling is used to inform exercise device requirements and validation for exploration class vehicles [1,2]



Biomechanical data collected on Earth and in microgravity during parabolic flight are used as input to the biomechanical models

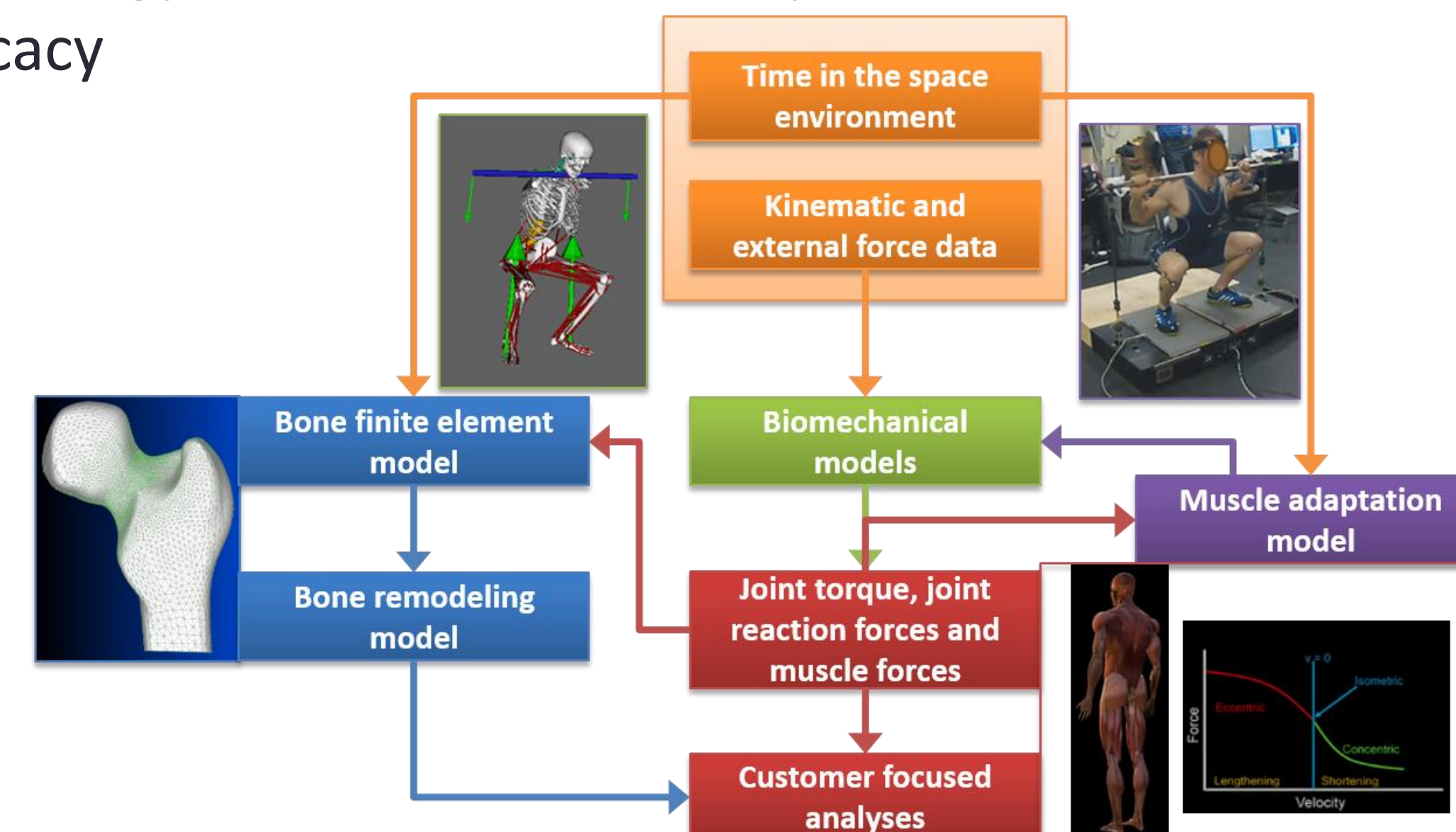


Joint torques and muscle forces are values that cannot be measured empirically and are therefore calculated with these models

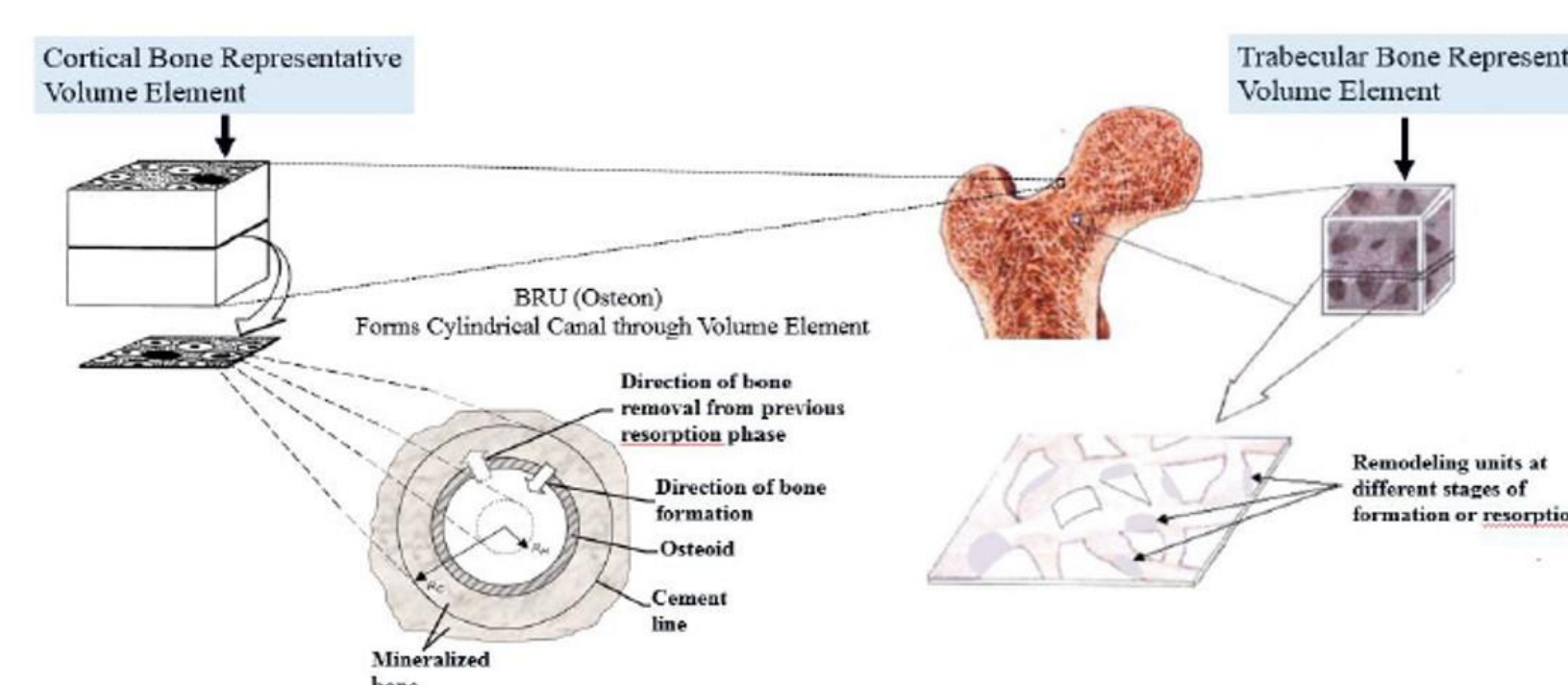
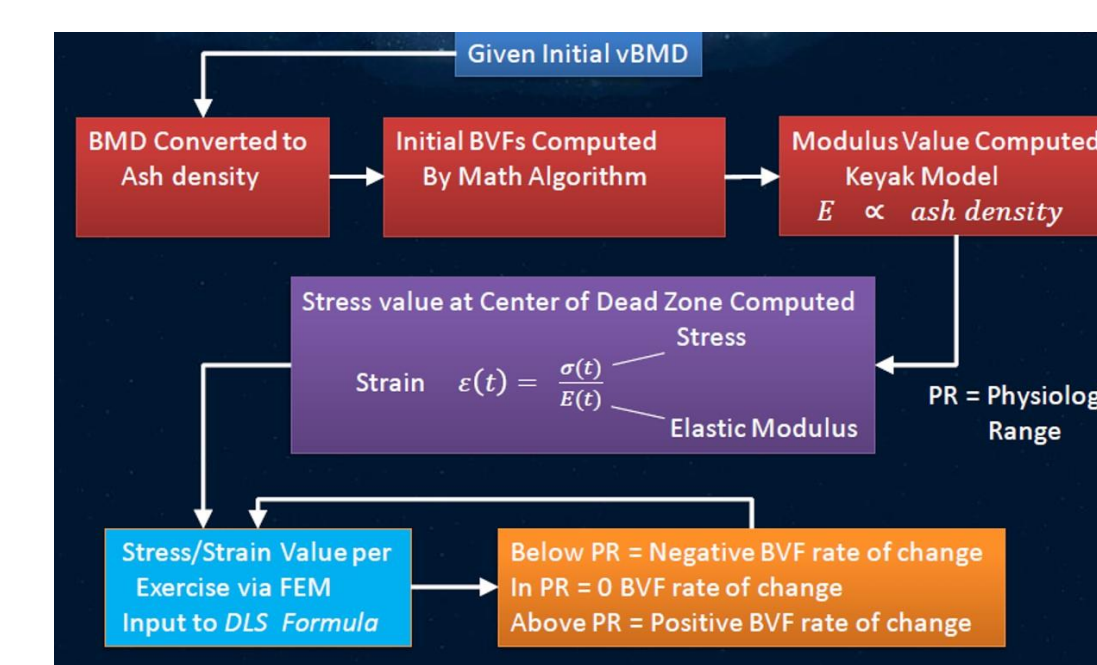


MUSCULOSKELETAL MODELING

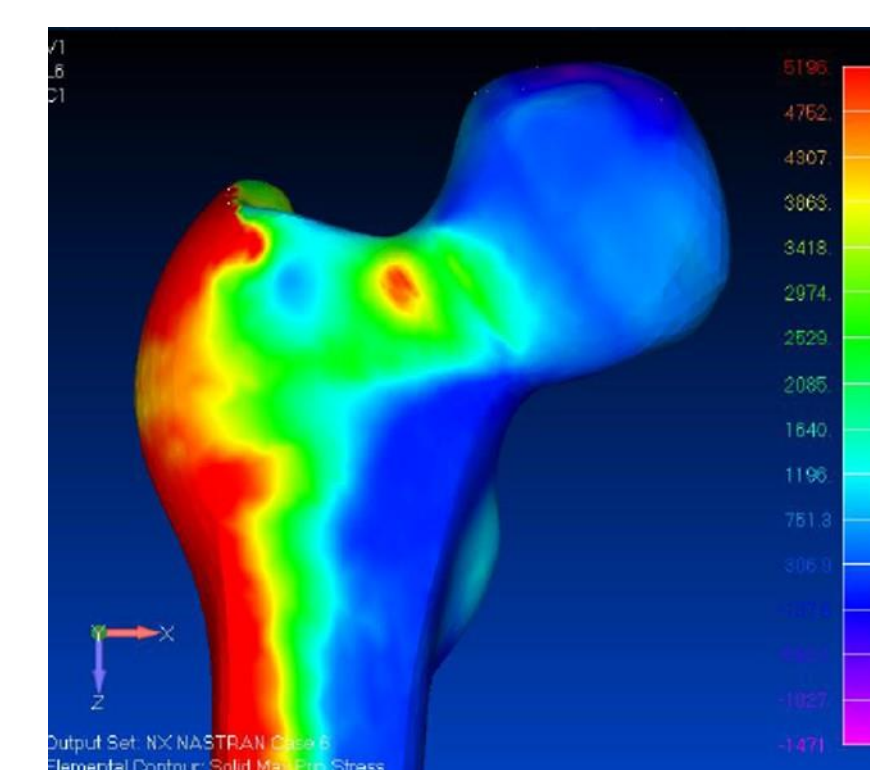
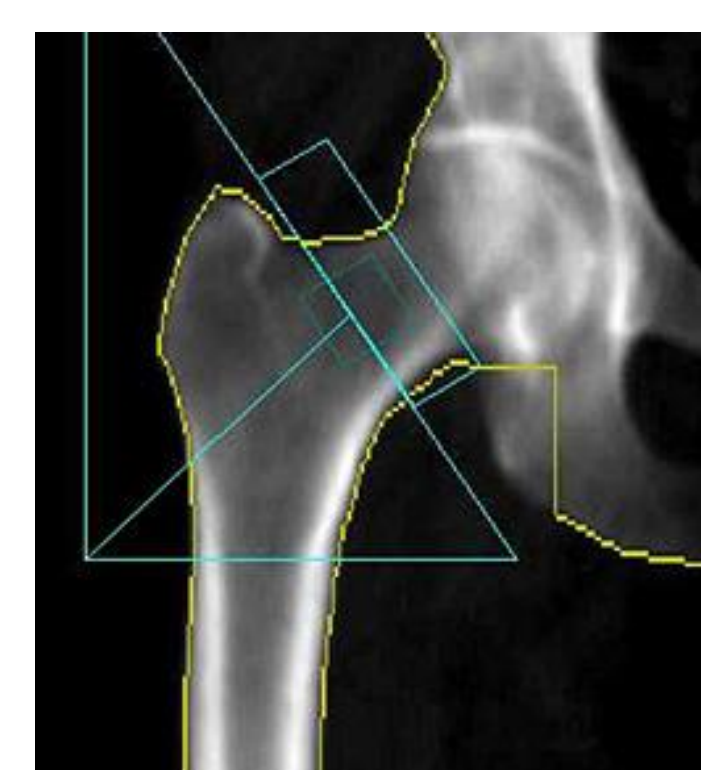
Integration of biomechanical models with bone and muscle space physiology models will allow for prediction of countermeasure efficacy



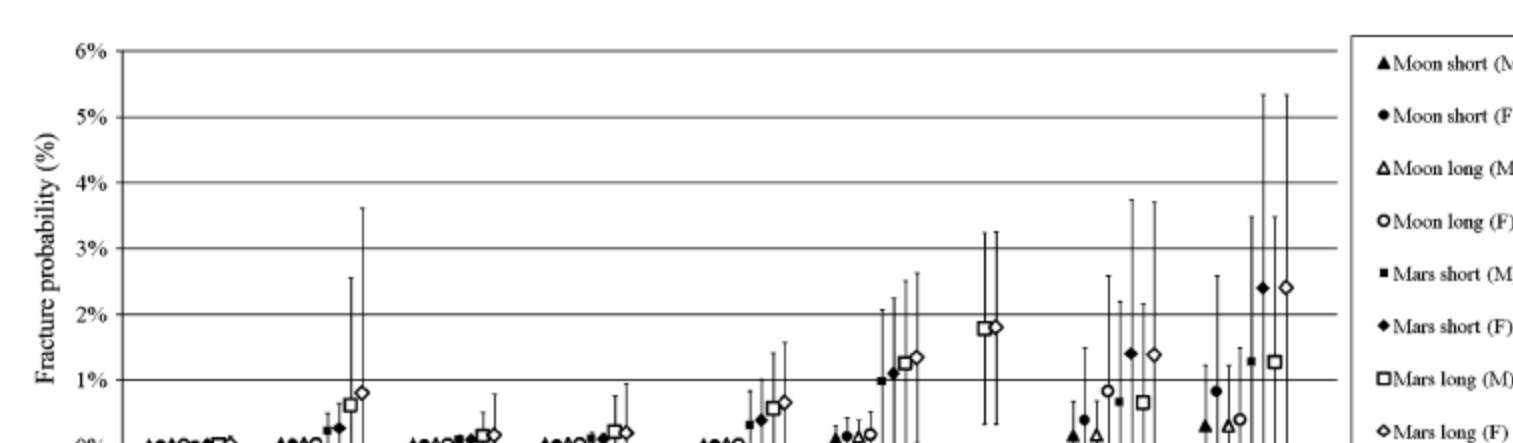
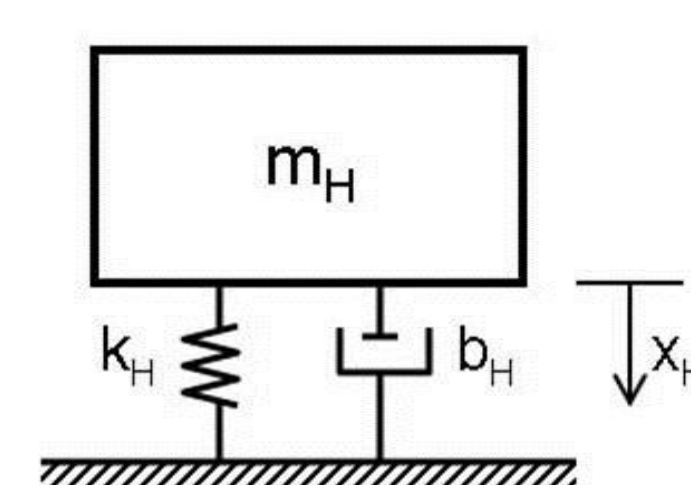
A key element of the bone physiology model is prediction of changes in volumetric bone mineral density during disuse deconditioning and resulting from mechanical stimulus [3,4]



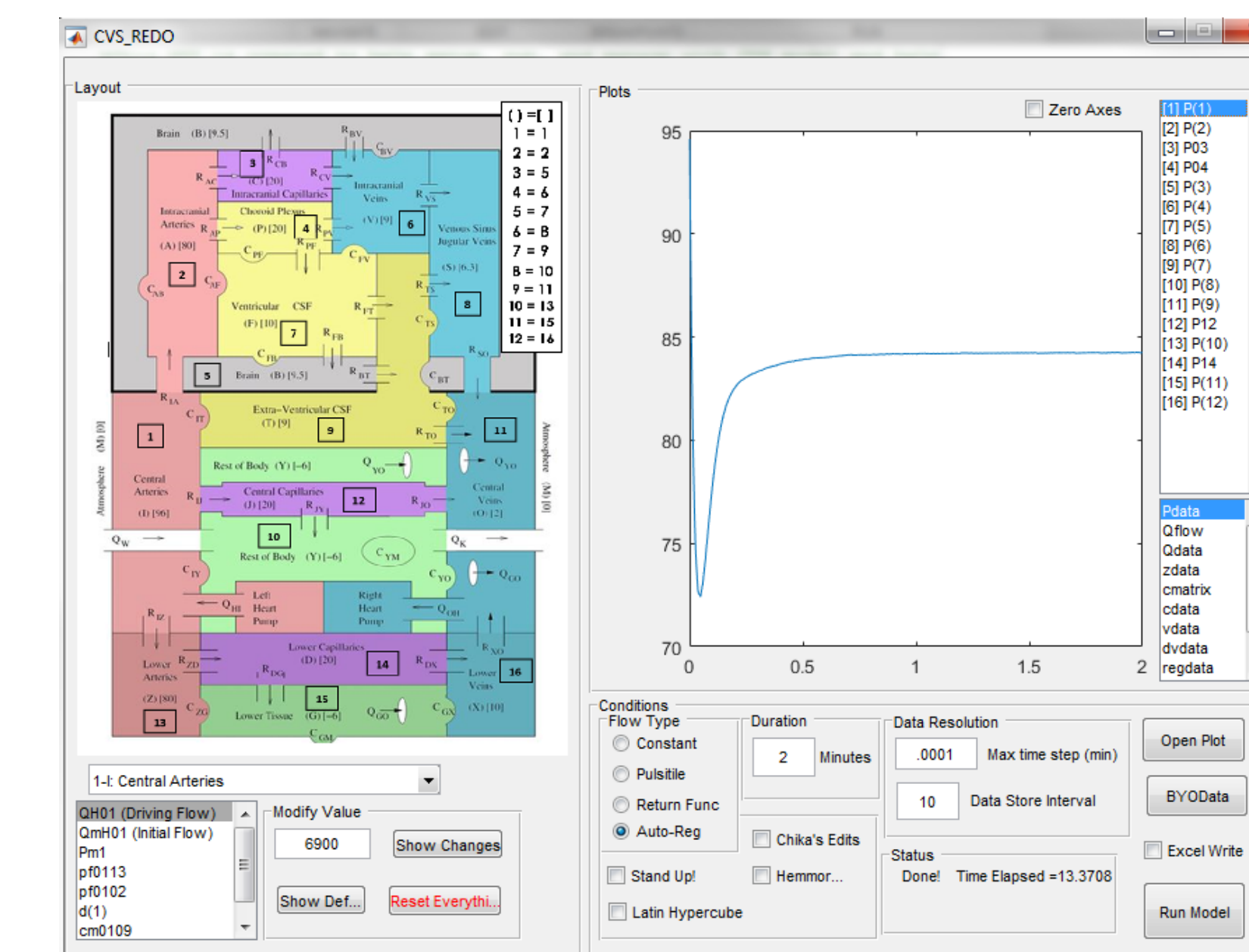
The bone models rely on pre- and post-flight astronaut bone mineral density measurements for model validation



Predictions of pre-, in- and post-flight bone fracture probability inform spaceflight bone fracture risk and drive countermeasure requirements [5]



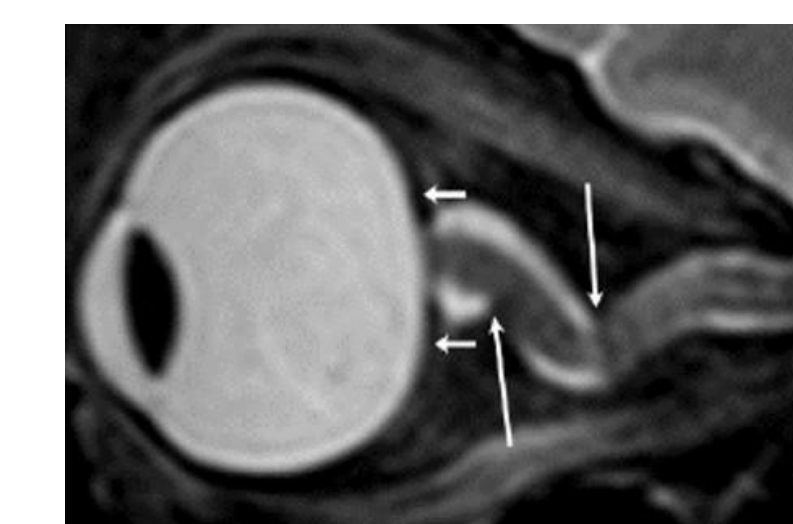
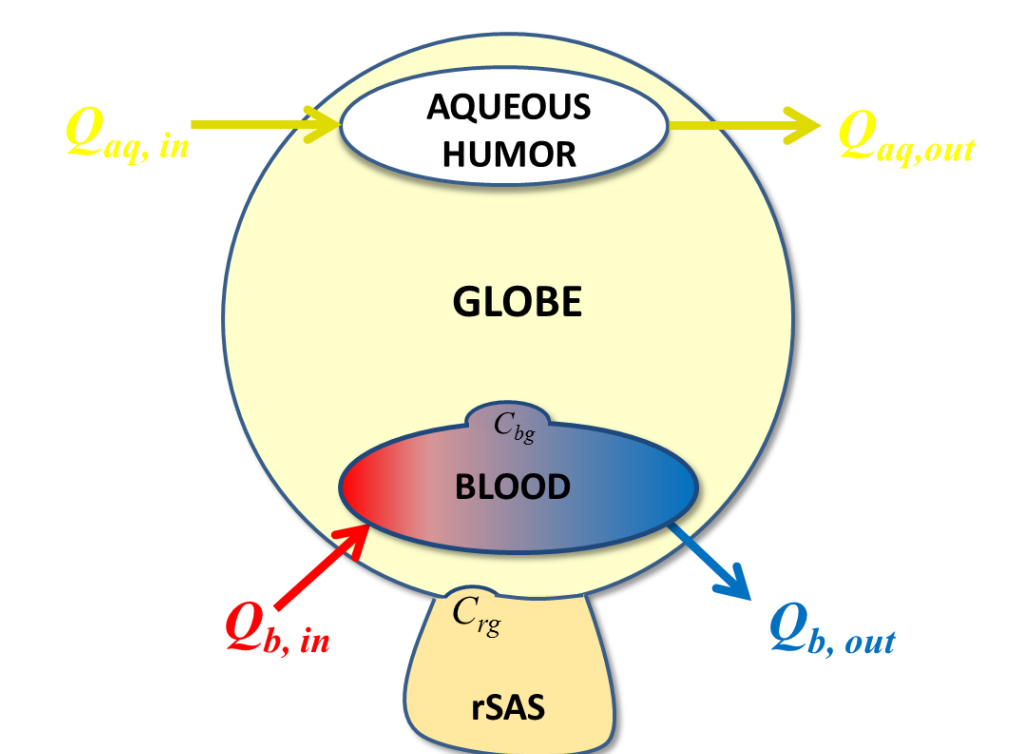
CARDIOVASCULAR MODELING



A lumped-parameter cardiovascular model, based on an existing model [6], calculates compartment volumes, pressures and blood flows resulting from a change in volume or posture and are used as initial values and boundary conditions within ocular models [7,8]

OCULAR MODELING

A four-compartment model of the eye quantifies volume, pressure and aqueous flow changes in the eye during gravitational changes [7]. Cardiovascular and ocular modeling are used to inform hypotheses about the visual impairment and intracranial pressure syndrome observed as a result of spaceflight.



This modeling relies on pre- and post-flight ocular imaging for model development and validation [9]

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